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OPERATING EXPERIENCES OF THE PHOTOVOLTAIC SYSTEM OF A BUSINESS CENTER THAT UTILIZES ENVIRONMENTAL ENERGY

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Abstract— One of today's most important research directions in the building sector is reducing energy consumption. In Hungary the residential sector is the biggest energy consumer with 40 % from the total energy consumption of the country. A possible way to decrease energy consumption is using renewable energy sources. In this work I show a short description of Photovoltaic cells and some measurements.

Keywords— Photovoltaic cells, electricity, operation, monocrystalline, polycrystalline, energy efficiency

I. INTRODUCTION

IN operation of our buildings, rising energy prices are forcing operators to save more and more. One of the most important research directions in the building sector is reducing the energy consumption. In Hungary the residential sector is the biggest energy consumer with 40% from the total energy consumption of the country. On the one hand we should minimize primary energy consumption, on the other hand the residual energy should be produced from renewable energy utmost. The latter is still only a small percentage ratio in our country, but the low of compulsory electricity takeover and government foundations have positive influence on spreading of these systems.

The question in case of such an investment is what kind of manufacturer and what type we should choose. The Renewable Energy Application Center in Debrecen had two main aims. One is to produce the largest part of the center's electricity by solar panels. The second purpose is to be able to compare the different types of solar cells and to be able to register the amount of the energy used continuously.

II. INTRODUCTION OF THE TEST SYSTEM

We have the opportunity to analyze seven different types of solar field data. This system fed to the power grid directly, (on-grid) so there is no need to install batteries. The supplier installs a digital meter, which allows measuring the quantity of regenerated our consumption, and solar cells' energy. One part of installed PV cells is monocrystalline, the other part is polycrystalline furthermore their manufacturer is different as well. In this system inverters are only the same, because each type feed to grid by SMA 3800 inverter.

Fig. 1. The installed PV system
Source: MEAK Debrecen

The solar modules have been installed on the warehouse roof structure facing south and 45° tilt adjustment. You can see the technical details of the currently installed system in the following table.

TABLE I
THE INSTALLED PV CELLS

Name	Nominal power	Number of moduls	Type	Amount of Power
1 field	250 Wp	16 piece	monocrystalline	4000 Wp
2 field	240 Wp	16 pieces	monocrystalline	3840 Wp
3 field	240 Wp	16 pieces	monocrystalline	3840 Wp
4 field	180 Wp	21 pieces	monocrystalline	3780 Wp
5 field	185 Wp	21 pieces	monocrystalline	3885 Wp
6 field	240 Wp	18 pieces	polycrystalline	4320 Wp
7 field	185 Wp	21 pieces	monocrystalline	3885 Wp

The solar modules and solar systems are characterized by the amount of power given to the units Wp. The letter "p" in "peak" refers to the English word for top performance. The definition of the element performance takes place under standardized conditions.

These conditions indicate the acronym STC (Standard Test Conditions) when the irradiation. 1000 W/m^2 , the temperature of module is 25 °C and the light spectrum of AM 1.5 standard. These "laboratory" conditions are not

realistic, so more and more manufacturers enter the parameters for the products of Noctem (Nominal Operating Cell Temperature).

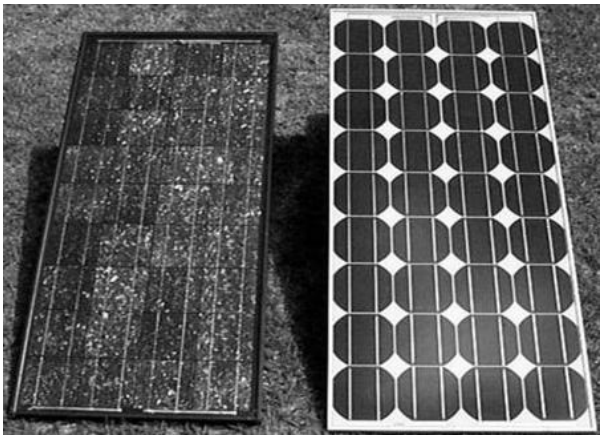

Fig. 2 The polycrystalline and monocrystalline PV cells
Source: http://asera.net/photovoltaics

In this case, the average temperature of cell or module is 45 °C, irradiation is 800 W/m^2, temperature of ambient is 20 °C, the light spectrum AM 1.5 the wind speed 1 m/s and module is aligned to south and an angle of 45 °.

Fig. 3 The installed PV cells
Source: MEAK Debrecen

If you manage to decide on the basis of technical and economic parameters which type of solar panel you want, design can be started. The majority of operating photovoltaic systems in Hungary, is in the category of so called domestic power which are under 50 kVA.

The main advantages of such a system are:

- No connection cost,
- The energy trader have to apply "balance accounts" in the accounting period
- The energy trader have to take the excess production
- No scheduling requirement
- No time limit for acceptance.

The MSZ HD 60 364-7-712 standard gives an accurate description for the construction of the solar systems. The major importance of the following criteria:

1. DC side of photovoltaic systems will also be deemed to be energized when the system is disconnected from the AC mains. Protection solutions used in the AC (alternating current) networks, such as DC (direct current) system with a TT or TN systems are constantly under stress can not be applied. Therefore, apparatus, appliance, cable and components used in the DC side must correspond to the double insulation requirements.
2. The DC side of photovoltaic systems, electrical connections must be the establishment of DIN EN 60439-1 regulations, in establishing the connection boxes, that only typed or partially typed solar cell junction boxes can be used a unique design that can not.
3. Electrical devices in the DC circuit comply with the DC voltage and DC current.
4. The solar cell junction boxes shall be provided with a warning label, which indicates that the active leaders in the can be considered to be under constant stress.
5. The relevant standards for almost all photovoltaic system designs require surge protection. This is ensured by the use of a lot of coordinated surge protection device selected. This means that a type 1 to the power supply point in a Type 2 device to the inverter AC side as well as BS EN depending on the safety distance of 62 305 lightning protection standards enforceability 1 or type 2 diabetes should the DC power network, the inverter DC side install.
6. On The AC-side of solar PV systems electricity supplied by the inverters performing DC / AC conversion has to be merged in an inverter connector box.
7. The wiring and cables of the photovoltaic system are need to be protected against short-circuit and overcurrent. Specially designed for photovoltaic systems, circuit breakers are used for this purpose frequently.
8. Keep the appropriate regulations in case of improper connection to a network and deliver our access point with safe and reliable components.

III. RESULTS AND EXPERIENCE

The photovoltaic system - according to the above mentioned standard - first-rate was completed in 2010. In this article we examined from 2011th October to 2012th October operating time. So we had the opportunity to gather operating information in mid-summer and in winter. In addition, we had the opportunity to collect solar radiation data near the installed system.

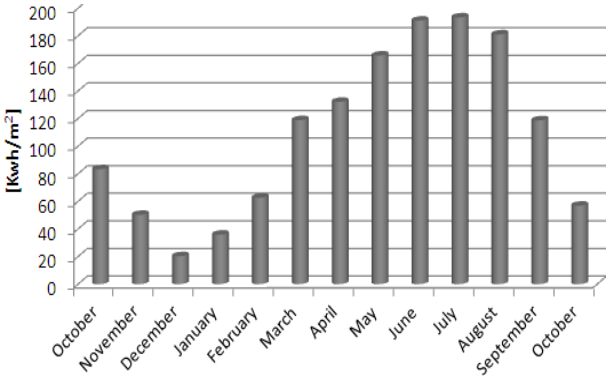

Fig. 4. The monthly distribution of solar radiation intensity in the period under review

Source: University of Debrecen, ATC Agrometeorological Observatory in Kismacs

As shown the monthly distribution of solar radiation intensity in the number 4 Figure. During the test period of 1m^2 per year from radiation intensity was ~ 1400 kWh/m^2 value (Dobos, Vígh, Molnár, Nagy, Kovács 2012.)

In practice, the quantity of energy from a 4 kW system – that consist of 16 pieces of solar panel- is able to use 94 kWh in the worst winter, while in the summer it can even use more than 570 kWh of electricity per a month. The average monthly distribution of 4 kW solar fields electricity utilization can be seen in the number 5 figure.

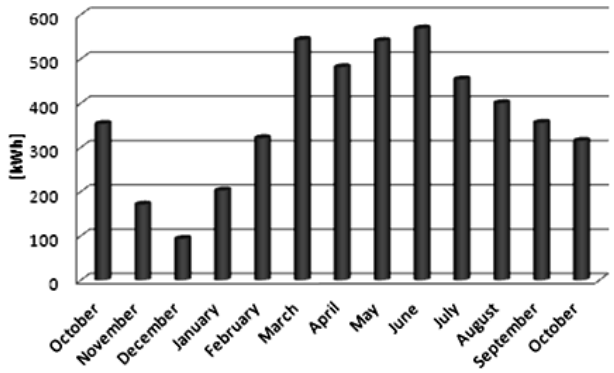

Fig. 5. The average monthly distribution of 4 kW solar fields electricity utilization

Source: MEAK Debrecen

Based on Figure 5's data installed solar panels could utilize solar energy on average ~ 13 % efficiency annually. Production rates were measured after the inverter, so this value is also included in the DC / AC conversion losses.

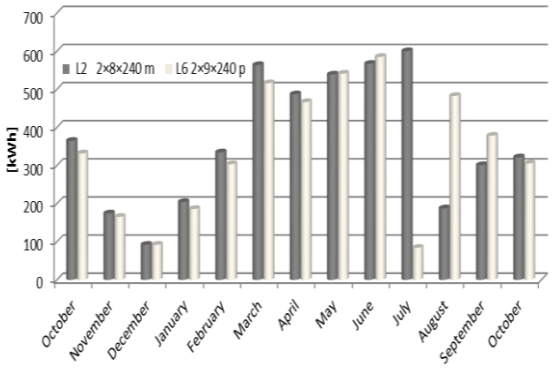

Fig. 6. The monthly distribution of 4 kW poly and mono solar fields electricity utilization

Source: MEAK Debrecen

Polycrystalline solar cell efficiency is lower than the monocrystalline solar cell, from the data shown in Figure number 6. It is important to note that the efficiency of solar cells depend largely on the temperature conditions and the installation of proper air flow must be ensured. (A. Hunter Fanney, Mark W. Davis, Brian P. Dougherty, 2006). This is a particular problem for warehouses like in this system. The outstanding value measured in March proves it too.

Polycrystalline solar cells have excess production during the winter, however if we test the annual amount, it is shown that the polycrystalline solar cell efficiency is only 10.6 %, while the monocrystalline efficiency is 12.8 %. If we take the domestic electricity prices 45 HUF/ kWh, then this performance difference means 13500 HUF per annual.

The other interesting question is if to choose a manufacturer from the East or from Europe. The solar panels are typically performance guaranteed, which is divided into two stages as a minimum of at least 90 % power for 12 years warranty and 25 years 80 % power warranty. Each manufacturer has agreed to the above terms and conditions of the guarantee for tested solar systems.

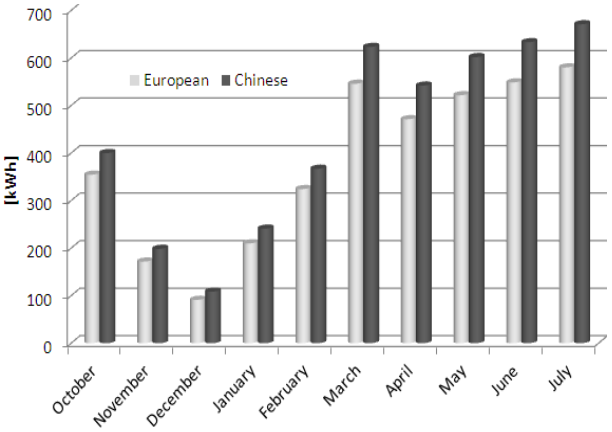

Fig. 7. The monthly distribution of Chinese and European solar fields electricity utilization

Source: MEAK Debrecen

Practical difference does not exist between the European and the Eastern Fields solar energy utilization yet. The monthly distribution is shown on Figure 7 - it is based on the two years after the installation-both systems utilized about 4,600 kWh of electricity annually, so more than 1150 hours worked. It is however worth to assess the results based on the data of several years of operating time. These results will be published in the future. In the meantime we can determine that based on the measured data there is no relevant differences between these high quality products. As far as possible you should choose solar cells which have available certifications and warranty papers.

IV. CONCLUSION AND RECOMMENDATIONS

About 4,800 kWh of electricity utilized a 4 kW system annually, which represents 216,000 HUF saving in overhead cost per year. Experience has shown that the amount of an average family of four will cover with same PV system.

It is important to choose a system where the source can be checked and the dealer has the appropriate documentation and warranty papers. So if the above mentioned product and performance warranty is available, it is advisable to buy the cells. In the measurement of time series analysis, it has turned out that regardless of their place of origin, solar panels with the same technical parameters work well.

The pivotal issue of renewable energy systems is economy. It can be seen easily that under the current foundation with this high current prices of these systems the payback period is 10-15 years, unfortunately. Costs are very high perhaps unduly, and the support system is also rudimentary compared to Western European countries. An important aspect that designers can draw the customer's attention to the fact that the building has to be operated and we can minimize overhead costs only with environmental and energy recovery systems. We also have to consider that primary energy prices are still better in our country than in the neighboring countries and, unfortunately, in the current economic situation, will not be sustainable for long. (István Farkas 2003)

It is also important to mention, that solar system can be a great supplement for the rising electricity use of the modern buildings. After all, we can heat the buildings with a heat pump and the solar system is able to produce the electrical energy for the heat pump. It must be noted that you should choose annual accounts from the traders because the annual power output of PV cells is not uniform. Another advantage of the solar system is that it does not contain any rotating, moving wearing parts, therefore it does not require any special maintenance. According to market researches, the largest price falls and the most important technical innovations can be experienced in this area. More and more buildings' electricity will be partially or fully resolved by solar panels, with reducing the amount of gas burned in power stations.

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